1) The development of new scintillator materials and doping agents has proven critical to the advancement of neutrino detector design. The new water based liquid scintillator (WbLS) in particular could enable a massive detector with a broad physics program at relatively low cost. Development of these materials is a critical step for future experiments, including optimization and characterization of the WbLS cocktail for different physics goals, large-scale attenuation measurements, and light yield studies at both low and high energy.

2) Isotope loading in traditional liquid scintillator, Gadolinium doping for water detectors, and the potential to load metallic isotopes in WbLS broaden the potential physics program and enhances the sensitivity of these experiments significantly.

3) Separation of fast, directional Cherenkov light from the slower yet far more abundant isotropic scintillation light would enable astonishing advances in signal identification and background rejection capabilities via particle identification. This potential capability should be explored via both optimization of the WbLS target, and alternate photon detection methods. The ability to reconstruct event energy and direction needs to be demonstrated both theoretically (in simulation) and in practice (in smaller scale experiments).

4) Large water Cherenkov detectors require very high purity water. Purification techniques for water are well understood in industry and need no R&D, but if additives are used (either isotope loading or a scintillator component) then the process will need to be modified.

5) Materials placed in water or (water-based) scintillator can impact the purity and the detector efficiency. A program to determine suitable materials must exist for future water and (water-based) scintillator detectors.

6) Water-based detectors (including WbLS) have the advantage of a low cost detector medium allowing very large-scale experiments. Future experiments will be limited by the cost and excavation techniques for the cavern needed to house the experiments. R&D to find lower-cost construction methods can facilitate next generation neutrino detectors.

7) A driving cost in large-scale water or scintillator detectors is the photomultiplier tubes. R&D to produce low cost, large area, ultra-fast, and possibly cryogenic photon detectors is important for the neutrino community. Ultra-fast, high precision readout will be critical to take advantage of developments in photon detector technology.

8) A comprehensive charged particle test beam program must be performed to characterize present and future LAr TPCs. This is necessary to calibrate the detector response of existing and future LAr detectors. This program should include electromagnetic and hadronic showers measurements, neutron cross section measurements, and energy deposition measurements with different charged particle beams typical for particles in future and present experiments.

9) R&D on the generation and breakdown of high voltage will reduce the risk to future LAr detectors and could lead to more monolithic and lower cost detector designs based on longer drifts. The causes of HV breakdown in LAr are not well understood. If the process for HV discharge in LAr is better understood then detectors could be designed for higher voltages (if the electron lifetime is sufficiently large). This could lead to larger cheaper detectors and could enable dual-phase style detectors. In addition the manufacture of LAr feedthrus for voltages above 100 kV has only been achieved successfully by a small number of groups.

10) The process of contamination generation and transport inside the large liquid argon detectors is not well understood. A program of measurements to study the sources of electronegative contamination in LAr detectors and the migration of contaminates throughout the detector systems is needed to insure the future detector design will meet specifications. The materials test stand at FNAL has provided critical insight into the contamination process in LAr detectors and continues to provide critical information needed for detector design. Future improvements to this system could be very beneficial.

11) R&D to study LAr properties should be supported. The impact of the dependence of charge recombination on the electric field and what impact it has on LAr detector calibration should be measured. First measurements of columnar recombination from ArgoNeuT exist but with large errors. Detailed studies of charge yield as a function of field, energy deposition, and track angle relative to the field should be performed. Other studies include more detailed measurements of the charge diffusion rates in liquid.

12) Present photon detector designs capture a very small fraction of the scintillation light generated in the LAr detectors. Detectors with better efficiency should be developed. Use of WLS/reflecting surfaces integrated into TPC structures should also be studied as a means increasing light yield.

13) The development of cold electronics for LAr detectors is critical. Advanced

designs for cold Pre-Amps and ADCs exist but a control chip is now in early stages of development. Development of electronics to read out large arrays of SiPMs cheaply is necessary to reduce cost of possible future photon detection systems.

Points to be covered in other sessions but need to be in the summary to DOE
Neutrino cross sections in the momentum range relevant for super nova physics need to be measured. - Neutrino interactions WG
The systematics near site to far site needs to be understood. LBN presentation
The reconstruction techniques for LAr TPCs need continuous development and refinement. LBN presentation, and others.